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(54) **Forming absorbent tissue paper products with fine mesh fabrics**

(57) A wet-laid, dry creped, bulky, absorbent tissue paper web of desirable softness and smoothness characteristics is produced utilizing a very fine mesh transfer and imprinting fabric. The wet-laid web is formed and through-dried in the absence of significant pressure to a consistency of from 40% to 90% and then carried on a fabric having between 4900 to 8100 openings per square inch to a creping cylinder. The fine pattern of the fabric is impressed into the web and the sheet is dried and creped. The tissue paper may be made using the apparatus shown. A two-ply product may be made using a nozzle headbox provided with a central divider.

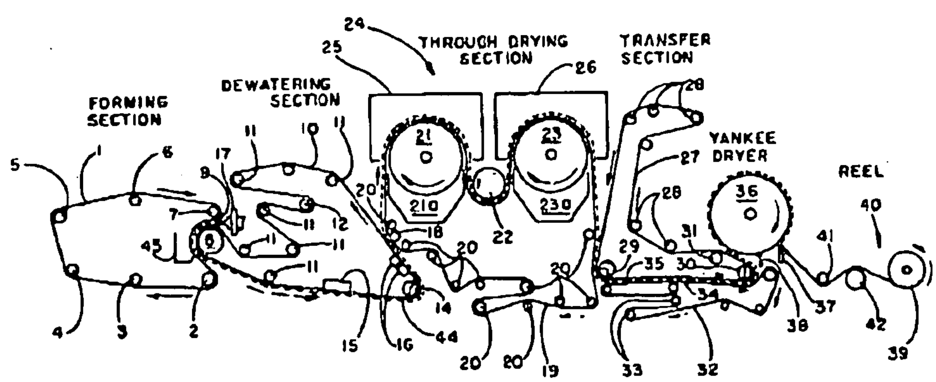

FIG. 1

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SPECIFICATION
Forming absorbent tissue paper products with fine mesh fabrics

This invention relates to wet-laid, dry creped tissue webs for use as facial tissue, toilet tissue, toweling and the like, and to methods for producing these improved webs and multiply sheets.

Creped tissue paper products for sanitary purposes such as toweling and facial and toilet tissues are conventionally produced by wet laying processes. These basically involved flowing an aqueous slurry of wood pulp fibres onto a wire, such as a Fourdrinier wire, of a papermaking machine, removing water from the slurry to an extent which permits removing the formed web from the wire, and further drying the web by pressing and including passing it to a heated "Yankee" dryer from which the substantially dry web is creped. The drying action causes the development of quite strong interfibre hydrogen bonds which impart strength to the web and also tend to increase its density and stiffness while correspondingly decreasing its softness. The creping action tends to disrupt some of the formed hydrogen bonds, releasing the fibres to an extent, that is, opening the web, and occasioning the development of absorbency, softness and bulk in the dried product.

It has been recognised that tissue webs, creped or uncreped, may be produced with enhanced absorbency, bulk and softness characteristics by limiting the extent to which fibre contact and hydrogen bonding occurs in manufacture. In the most usual method of production it is customary to drain water from the aqueous slurry on the papermaking wire with the aid of suction boxes, table rolls and the like. The slurry, which initially may be 0.3% fibre by weight and 99.7% water, is increased in consistency by such actions to a point where the web may be mechanically pressed. The mechanical action, while useful to remove large quantities of water and to thus increase the web consistency, tends to pack the fibres more closely together, thereby increasing the hydrogen bonding of the fibres and web density as already mentioned. Various proposals to avoid this compaction of the web and to attain a soft, absorbent product with a high strength, have been suggested but more have been entirely satisfactory.

Tissue web sheets in accordance with the present invention have a basis weight in the range of between about 5 and 25 pounds per 2880 sq. ft. and a knuckle pattern occupying between about 20 and 25% of the web surface area, said knuckle pattern being that of an imprinting fabric having greater than 4900 openings per square inch and less than about 8100 openings per square inch. Such webs are designed to have characteristics suiting them for their stated purposes and, in addition, to be of more acceptable softness and smoothness than is generally present in these products.

It is totally unexpected, that a light weight paper web suitable for use in facial tissue applications, for example, may be imprinted with such a very fine mesh fabric to provide a high bulk, absorbent and soft product. The relatively fine mesh fabric commonly would be expected, to produce a smoothed out and overall compacted web similar to that attained by overall pressing of the web with a papermaker's felt. But contrary to expectations of this order, the web produced has significant densified areas formed under the knuckles of the fine mesh transfer and printing fabric with bulked areas lying between to give the web desirable bulk, softness and absorbency characteristics.

The present invention is based upon the finding that a very fine mesh fabric will impart to a tissue weight web of a fibre consistency in the range of about 40% to 90%, a significant imprint to cause fibre bonding which, overall, gives satisfactory strength so that the product is useful in commercial tissue applications. Simultaneously, the tissue conforms sufficiently to the mesh openings to create bulked zones to provide an improved tactile response. The creped webs produced are characterised by a very fine crepe structure and, importantly for tissue applications, a smooth surface, absorbency and a high degree of limpness for the strength level of the web.

Thus a process for the production of a smooth tissue in accordance with the invention comprises the steps of wet forming a paper web of wood pulp fibres in the substantial absence of pressure to minimize interfibre bonding, through-drying the formed unpressed web to a fibre consistency in the range of about 40% to about 90%, carrying the so through-dried web on an imprinting and transfer fabric having between about 4900 to 8100 openings per square inch and imprinting the knuckle pattern of the fabric into the web to provide bonded zones and bulked unbonded zones between the bonded zones while continuing drying of the web, and creping the bonded web to provide a web of at least about 70 crepes per inch and having a high degree of smoothness.

The extent to which the web is through-dried, that is, subjected to drying without significant mechanical pressure before application to the creping drum, is dependent to some degree upon the characteristics desired in the final product. Roll products of high bulk such as bathroom tissue are preferably dried to the upper level of the 40% to 90% consistency range before being applied to the creping cylinder. Products such as facial tissue where surface smoothness and strength are usually considered to be the dominating characteristics may suitably be through-dried to the lower or middle level of the consistency range and they will give a finer degree of crepe and smoothness. Kitchen towels may similarly be provided to emphasize the characteristics of smoothness in preference to bulk, and this will determine the degree to which the web is through-dried.

The moist web, that is, at 40% to 90% fibre consistency, may be adhered to the dryer using a polyester fabric of about 70 or more meshes per inch and suitably of a fourshed twill weave fabric. Such a fabric has a filament or thread pattern in which the warp passes through the shute strands in a three-

under and one-over pattern providing long chute knuckles which lie against the web. Other weaves, however, may be employed.

The web product of this invention may be produced in a basis weight useful as a single ply but a sheet product of two webs is more usual.

The invention provides a tissue web of enhanced softness while get providing a web of good bulk and absorbency characteristics.

The invention will now be further described with reference to the accompanying drawings wherein:

Figure 1 is a schematic illustration of a papermaking machine useful for the production of creped tissue webs in accordance with the invention;

Figure 2a is an enlarged and schematic illustration of an uncreped product formed on the papermaking machine of Figure 1 employing a fabric of about 5616 openings per square inch (78x72 mesh) as the printing and impression fabric;

Figure 2b is a view similar to that of Figure 2a but of a creped product;

Figure 2c is a view of a printing and impression fabric of about 5616 openings per square inch (78x72 mesh) employed to produce the product of Figure 2b;

Figure 2d is a view similar to that of Figure 2c but of a printing and impression fabric of about 775 openings per square inch (31x25 mesh):

Figure 2e is a view similar to that of Figure 2b but with a fabric of Figure 2d;

Figure 3 is a perspective view of a two-ply tissue product employing the tissues of Figure 2a but each with a sine wave arrangement;

Figure 4 is a perspective view of a two-ply tissue product employing the tissues of Figure 2a but each embossed with a peg-on-peg arrangement;

Figure 5 is a schematic illustration of another arrangement of a papermaking machine adapted to provide a multilayer web;

Figure 6 is an enlarged and schematic illustration of a two-ply product in accordance with the invention in which each ply is formed on a papermaking machine having a divided inlet as shown in Figure 5 and with a printing and impression fabric of about 5616 openings per square inch (78x72 mesh) as in Figure 2a;

Figure 7 is an enlarged and schematic illustration of a two-ply product similar to that of the prior art but formed with a printing and impression fabric of about 1200 openings per square inch (40x30 mesh).

Referring initially to Figure 1, the papermaking machine is generally known except for the nature of the fabric in the transfer section and its relation to the through-drying and creping roll sections.

The papermaking machine in the forming section comprises a loop of a forming fabric or wire 1 which is trained about a plurality of rolls 2, 3, 4, 5, 6, 7, and 8. The fabric 1 is a conventional paper web drainage wire or fabric used in Fourdrinier machines and the strands may be of either metal or synthetic fibre material. The roll 8 is somewhat larger in diameter than the other mentioned rolls and serves as a slice roll. The roll 7 which has its centre in vertical alignment with the roll 8 serves as a breast roll and the rolls 7, 8 define a forming zone 9 into which stock is discharged for sheet formation. The rolls 2, 3, 4, 5 and 6 are turning rolls. Roll 5 also functions as a guide roll having one end fixed and the other movable and any suitable apparatus (not shown) may be connected with the movable end of the roll so that the roll functions to cause the fabric 1 to track. Roll 1 may be suitably equipped to be movable to provide for maintaining adequate tension in the forming fabric. One or more of the rolls such as slice roll 7 or couch roll 2 may be driven for the purpose of driving the fabric 1. Any suitable doctors and water showers may be used in connection with the forming fabric in its travel to maintain the fabric clean as is well known in the art.

The dewatering section of the machine includes a drainage fabric 10 disposed about a plurality of rolls identified at 11, 12, 13 and 14. Also, the fabric 10 passes around roll 8 and, with the fabric 1, constitutes the forming zone 9, the fabric 1 lying outside the fabric 10.

The roll 12 is a conventional stretch roll having both ends simultaneously adjustably moveable by mechanism (not shown) for maintaining the loop of fabric 10 tensioned about the plurality of rolls supporting the fabric. Roll 13 is a conventional guide roll for maintaining fabric 10 in a predetermined path.

Roll 14 is somewhat larger than the remaining rolls 11 and is positioned closely between suction or vacuum box 15 and a plurality of vacuum boxes 16 which immediately precede the zone of formed web transfer. The plurality of rolls 11 serve as supporting and turning rolls.

A headbox indicated at 17 provides for directing the usual aqueous pulp furnish to the forming zone 9 between the fabrics.

The numeral 18 designates a vacuum pickup shoe bearing the inside of a through-drying fabric 19. The fabric 19 is suitably a relatively open polyester fabric which passes over a plurality of small supporting rolls 20 as indicated and over a first open honeycomb through-drying roll 21, a large guide roll 22 and a second open honeycomb through-drying roll 23. The through-drying section is itself designated generally by the numeral 24 and includes hoods 25, 26 over the through-drying rolls 21, 23 respectively. In this arrangement heated air supplied by the hoods is directed through the through-

drying fabric on the rolls 21, 23 and is exhausted through outlets 21a, 23a.

The through-drying section 24 is followed by a transfer section. This section includes a carrying and imprinting transfer fabric 27 of relatively fine mesh. The fabric is suitably of single filament structure having a mesh in the range of about 70 to about 96 meshes per inch. The fine mesh fabric 27 is supported by a plurality of carrying rolls 28, vacuum pickup roll 29, vacuum couch roll 30 and press roll 31. The transfer section also includes fabric 32 supported by a plurality of turning rolls 33 and having an upper run 34 which lies along the lower run 35 of fabric 27. At least one of the turning rolls 33 is adapted as a take-up roll in conventional fashion. Another roll 33 is preferably equipped to aid tracking of the fabric and one of the rolls 33 suitably is a drive roll.

The roll 31 presses the combination of the fabric 27 and any web carried thereon to the creping drum or Yankee dryer 36. This drum 36 is steam heated and serves to dry a web passing over it as the web approaches the creping blade 37. Adherence of a web to the dryer is attained usually with the aid of an adhesive which may be applied either to the web as it passes to drum 36, or it may be applied to the drum itself by a spray head shown at 38.

The dryer section is followed by the reel section 40 which includes rolls 41, 42, the reeled material being designated at 39.

In the operation of the apparatus of Figure 1 a web 44 formed in the zone 9 is dewatered as indicated by movement of withdrawn water to receiver 45. The web has a fibre consistency of about 8—10% as it leaves roll 8 and parts from the fabric 1. Dewatering further occurs at rolls 11 as web 44 is carried by the fabric 10 on its underside. Further de-watering, without significant pressure but some minor fibre bonding due to web shrinkage upon water withdrawal, occurs at vacuum boxes 15 and 16. The web at a consistency of about 30—35% is transferred to through-drying web 19 which carries it over rolls 21, 22 and 23, drying the web to a consistency in the range of 40—90%. The relatively fine mesh fabric 27 accepts the through-dried web at roll 29 and the web is transported between fabrics 27 and 32 to the inlet to the Yankee dryer at press roll 31.

Adhesive is usually applied to the dryer through spray head 38 to control the degree of adherence of the web to the dryer. The application of the adhesive may be to the web itself or to both the web and dryer but, commonly, application to the dryer is preferred. The control of the creping action by controlling the sheet adhesion to the dryer is a well-known art. In some cases the web applied to the dryer may itself have sufficient tack that no adhesive is necessary and, in some cases, a release agent is employed to decrease adhesion and to aid maintaining the dryer surface clean of fibre, resin and the like. Adhesives which serve the purpose of control of the web adherence include animal glue, water soluble polymeric materials, water dispersible resins such as polyvinyl alcohol, polyvinyl acetate and vinyl acetate ethylene copolymers, vinyl resins in organic solvents, starches, plastisols and the like.

A product of the machine operation of Figure 1 is illustrated in Figure 2a. The web 44 has a series of compressed zones 44a corresponding to the knuckles of the fine mesh fabric 27 and bulky zones 44b bordering the compressed zones. The fine crepe structure of the product is indicated at 44c in Figure 2b. The fabric itself is indicated at 27 in Figure 2c. The illustration in Figure 2d is of a fabric 46 of the prior art having a mesh of about 31×25 (775 openings per square inch) and Figure 2e illustrates a product 47 formed with the fabric of Figure 2d.

Figure 3 illustrates a two-ply product formed by bringing together two plies of the tissue webs 44 of Figure 2 in accordance with U.S. Patent 3,868,205, the subject matter of which is incorporated herein by reference. In Figure 3 the sheet generally designated by the numeral 48 is embossed in each web and crossing peaks 49, 50 of the embossments are secured together by an adhesive 51 applied to one of the embossed webs.

Figure 4 illustrates a two-ply product formed by bringing together two plies of the tissue webs 44 of Figure 2 in a peg-on-peg type embossment in a manner known to the art. In this arrangement each embossed web has protuberances 53 and bordering zones 54 with the webs mating on the protuberances and held together by adhesive 55. The fine crepe structure of each web is designated at 56.

A multi-layer web may be produced utilizing the papermaking machine of Figure 5. In this instance the general nature of the equipment and its mounting are similar to that described in connection with Figure 1 except that a divided inlet is employed and the same fabric carries the formed web through the through-dryer to the Yankee for web imprinting, and the machine operates at a somewhat lower speed. As illustrated, inlet 60 has a divider 61 so arranged as to permit the supplying of one furnish through chamber 62 and another through 63 so that layering of the furnishes is accomplished as the stocks flow to the forming fabric 64. A dewatering vacuum box 65 is associated with the forming fabric which is supported by a plurality of large rolls 66 and a plurality of smaller rolls 67. A fine mesh fabric 68 kiss contacts the forming fabric 64 and accepts, with the aid of vacuum pickbox 69, a formed web carrying it as indicated by the arrows past vacuum dewatering box 70 and through the through-dryer 71. The through-dryer is schematically illustrated and may be of the type in which an open circumference roll is supplied with heated air from a hood in such manner that the heated air passes through the web to the interior of the roll, or may be so arranged that the heated air is supplied internally of the roll to pass through the surface of the hood. The fine mesh through-drying and imprinting fabric is suitably supported by a plurality of rolls 72 of small diameter and a plurality of somewhat larger rolls 73 arranged to cause tracking movement of the fabric in known manner.

One roll 73 is the press roll for urging the fabric 68 and web 74 thereon to the surface of the Yankee dryer 75. A nozzle 76 provides for a spray of adhesive and a creping blade 77 is arranged to crepe the relatively dry web from the dryer. The creped web is tensioned by roll 78 and reeled at 79.

A web may be produced with the equipment of Figure 5 to provide a double layer web or removal of the divider 61 permits a single layer web to be formed.

Figure 6 illustrates a two-ply sheet 80 formed of webs 81, 82 each of which is produced in a machine as illustrated in Figure 5 having a fine mesh fabric 68 and which sheet has been edge crimped as at 83 to securely retain the plies.

Figure 7 illustrates a two-ply sheet 85 made of webs 86 of a single furnish in equipment similar to that of Figure 6 but in which the fabric 68 is a relatively coarse mesh fabric having a count of 40 by 48 with 1920 openings per square inch.

The following Examples 1 to 4 inclusive illustrate the effect of using a relatively fine mesh impression and transfer fabric as compared to a relatively coarse mesh impression fabric in producing a kitchen towel product form from a through-dried base web. Through-dried towelling base web material was manufactured from a single furnish. In one instance a coarse transfer and impression fabric 31×25 mesh with 776 openings per square inch and in a second case a relatively fine transfer and impression. fabric of about 78×72 mesh with about 5616 openings per square inch were used to produce the base webs. All machine conditions other than the fabric mesh were held as constant as possible. The use of the coarse mesh fabric simulates a prior art procedure for the manufacture of base webs while the use of the fine mesh fabric demonstrates the advantages of the present invention. In this comparison through-drying took place on one fabric in each instance and the web was then transferred to the test fabrics for transport to the dryer (Figure 1).

The two through-dried towelling base sheets produced were then each converted to finished rolls of towels by two different processes and tested in a paired comparison against a leading commercial towel obtained at a retail store.

EXAMPLE A

A continuous web of paper was manufactured (Figure 1) at a speed of about 2500 fpm from a furnish consisting by weight on an air dry basis of 62.5% northern softwood kraft, 20.8% northern hardwood kraft, and 16.7% machine broke of the softwood and hardwood. Approximately 0.9% Parez NC631, purchased from American Cyanamide, a resin which provides both wet and dry strength, and 0.6% Kymene 557 of Hercules Chemical Company, a commercial wet strength resin, was added to the furnish in the pulper for wet and dry strength control, and the pulps and white water system were adjusted to 6.5 pH with muriatic acid. The mixed furnish was lightly refined and supplied to a tissue machine equipped with a forming section as in Figure 1. The dewatering section and pre-Yankee through-drying section, the transfer and impression section and Yankee dryer were also as in Figure 1.

The tissue web 44 (Figure 2) was formed between the two fabrics 1 and 10 at a target dryer basis weight of 12.0 lbs/2880 ft^2 in the forming section at 9 (Figure 1). The fabrics 1 and 10 were conventional commercial fabrics. The formed sheet was further dewatered while on the inner fabric using vacuum boxes 15, 16 and transferred to through-drying fabric 19 by means of a vacuum pickup shoe 18 operating at 8" Hg vacuum. The consistency immediately after the transfer was 27.7%. The moist web 44 was predried on the through-drying fabric by pulling heated air through the web and through-dryer supporting fabric 19 to a fibre consistency of 80%. The partially dried web was then transferred to polyester fabric 27, carried between the fabric runs 34, 35 to the Yankee dryer pressure roll 31, and pressed against and transferred to the Yankee dryer at a pressure of 200 pli by a 40 P&J hardness rubber covered roll 31 acting through the fabric 34 and moist web 44 to the Yankee dryer 36. A minimum amount of creeping adhesive consisting of an aqueous solution of polyvinyl alcohol and a small amount of tetra-sodium pyrophosphate was sprayed onto the Yankee dryer immediately ahead of the pressure roll nip at roll 31 to control adhesion of the moist web to the Yankee dryer.

The impression and transfer fabric 27 is a four-shed twill weave polyester fabric having 78 meshes/inch in the machine direction and 72 meshes/inch in the cross machine direction (5616 openings per square inch). The warp and shute wires were 0.0079" in diameter and the fabric was lightly surfaced by sanding on the impression side. The impression fabric knuckles were estimated to compact about 20% of the web surface.

The moist web 44 adhering to the Yankee dryer 36 was then dried to a final dryness of about 95% creped from the surface of the Yankee dryer by blade 37 and wound into rolls on the reel at 40. The creping blade 37 was ground with a 10° bevel and was held against the dryer 36 to maintain a creping pocket of about 80°. The ratio of yankee dryer speed to the reel speed was maintained at about 1.30 resulting in a finished base web having about 30% residual stretch.

The through-dried base web having a basis of about 12 lbs/2880 sq. ft. and having the physical properties shown in Table 1 was then converted into finished kitchen towel product forms using two different embossing patterns and employing converting processes as follows:

EXAMPLE 1

A sheet 48 (Figure 3) was produced by first separately embossing two webs of the base sheet

described above with continuous sine wave patterns in accordance with U.S. patent 3,868,205, by passing each web individually through the nips formed by patterned steel and rubber covered rolls. Printing adhesive was disposed in discrete areas on the raised embossed inner surface of one of the webs, then the two webs were brought together to promote ply attachment in the adhesive printed areas. The two-ply embossed glued towel was then perforated at 11" intervals and wound into a finished towel roll containing 100 sheets.

The continuous embossed sine wave patterns were at opposite directed 45° angles to the direction of the web travel and the adhesive used was an aqueous dispersion of polyvinyl acetate. The finished towel rolls containing 100 sheets were cut to 11" width. Physical properties of the finished towels are shown in Table II

EXAMPLE 2

The same base webs utilized in Example 1 were converted to a finished towel product form using a different towel coverting process and embossing pattern. This converting process is termed frequently a peg-on-peg structure and is an embossment employed commercially. Two webs are separately embossed with a raised pattern of discrete embossed protuberance by passing them individually through nips formed by steel embossing rolls and rubber covered embossing rolls. The embossed pattern on each of the webs was identical. An aqueous dispersion of polyvinyl acetate adhesive was then printed on the raised, embossed inner surface of one of the webs and the two webs remaining in arcuate contact on the identical patterned embossing rolls were brought into contact in the nip formed by the two steel embossing rolls so that the distal surfaces of the embossed protuberances were indexed and adhesively bonded. The two-ply, embossed glued towel was then perforated at 11" intervals and wound into rolls containing 100 sheets, these rolls were cut into 11" widths and tested with the results also as shown in Table II.

EXAMPLE B

Another base web was produced similar to that of Example A except that the transfer and impression fabric 27 was a surfaced semi-twill weave fabric identified as of 31×25 mesh (775 openings per square inch).

Furnish additives and operating conditions were maintained as closely as possible to the conditions used in the production of the base sheet for Examples 1 & 2 except for the use of the coarser fabric. The machine was operated at 2500 fpm and the target dryer basis weight of 12.0 lbs/2880 ft². The fibre consistency entering the through dryer was at 25.1% and at 87.0% leaving the through-dryer section; the partially dried web was then pressed against the Yankee dryer surface at a pressure roll 31 loading of 200 pli with the pressure being applied through the polyester transfer and impression fabric 27 so that the web was imprinted with the back side of the fabric. The web was dried, creped and wound into a roll in the same manner as shown in Examples 1 and 2. Physical characteristics of the base web are shown in Table I.

EXAMPLE 3

The base web of Example B was converted to finished 100 sheet count two-ply web towel rolls in a manner identical to that of Example 1. The physical properties of the towels are shown in Table II.

EXAMPLE 4

The base web of Example B was converted to finished 100 sheet count two-ply web towel rolls in a manner identical to that Example 2. The physical properites of these towels are also shown in Table II.

TABLE 1

	Finished Basis Weight Lbs/ 2880 Ft²	TENSILE STRENGTH (1 PLY) Grams/3" Strip				ABSORBENCY Rate Sec.	CAP Gm/Gm	20 PLY BULK Inches
		MD	Stretch	CD	Wet CD			
Fine Mesh Base Sheet Example A	15.8	1375	29.8	1135	240	2.4	7.5	0.158
Coarse Mesh Base Sheet Example B	15.9	1270	30.7	1090	245	2.2	7.7	0.181

The calculated bulk density of the base web of Example A is 2.2. grams per inch cube at a loading of 220 grams per square inch while the crepes per inch are about 83 at an adjusted basis of 20% stretch; this is in contrast to a bulk density value of 1.93 for the coarse prior art material of Example B

which exhibits about 37 crepes per inch at 20% stretch on the same adjusted basis. Crepes per inch are related to the residual stretch characteristics of the web and, therefore, the data are stated on the basis of crepes per inch at a standard stretch of 20%. The 20% level is chosen because most commercial tissue is marketed at a 20% stretch level.

TABLE II

Physical Properties of Towels

	Examples 1	2	3	4	Commercially Made Throughdried Towel
Base Webs	Ex. A	Ex. A	Ex. B	Ex. B	
Basis Weight Lbs/2880	29.1	29.8	29.5	30.5	30.9
Tensile Strength — Gms/3"-MD-Dry	2130	2585	2400	2516	2380
Tensile Strength — Gms/3"-CD-Dry	1710	2045	1710	2150	1970
Tensile Strength — Gms/3"-CD-Wet	425	498	416	475	680
% Stretch — MD	19.8	22.8	17.5	21.9	23.1
Absorbent Capacity Gms H_2O/Gm Fiber	8.1	8.2	7.2	8.1	9.1
Absorbent Rate — Seconds	3.0	2.4	2.8	2.2	3.7
Handle-O-Meter-MD	3.0	4.2	3.0	3.9	5.4
Handle-O-Meter-CD	7.0	10.2	7.2	13.8	9.0

The following Examples 5 and 6 illustrate the effect of using a fine mesh, through-drying, transfer and impression fabric 68 to produce a through-dried facial tissue product form and compare it to a through-dried facial tissue produced using a plain weave coarse fabric of the prior art as a through-drying and impression fabric. The comparison is not a strict one as a high quality virgin furnish was used to produce the facial tissue made by the simulated prior art process while the fine mesh fabric example was made with about 50% secondary fibre in the furnish and was a layered product as described in co-pending application Serial No. 828,729 filed August 29, 1977.

EXAMPLE 5

A two-layer web was formed using an inlet equipped with a flexible divider that kept the two different stock supplies separated until they were formed as shown in Figure 5. The web was formed at a total dryer basis weight of 7.0 lbs/2880 square feet at about 75 fpm. The basis weight of the layer which lay adjacent to the Yankee dryer surface and the creping blade 77 had a dryer basis weight of 4.0 lbs/2880 square feet. This layer was made up of a furnished consisting of 75% northern softwood kraft and 25% northern hardwood kraft which had been lightly refined and contained 0.5% of a conventional wet strength resin, Kymene 557, a product of Hercules Chemical Company. The opposite fibre layer consisted of 100% pre-processed secondary fibre and had a dryer basis weight of 3.0 lbs/2880 ft^2.

The formed two-layer web was dewatered to about 20% consistency on the forming fabric 64 with vacuum boxes and transferred to fabric 68 through the aid of vacuum shoe 69. Fabric 68 was a polyester fabric, monofilament, of 78×72 mesh as in Example A. Hot air at about 180°F was then blown through the web supported by the through-drying fabric 68 until the web reached a consistency of 75 to 80%. The moist web was then pressed against steam heated dryer 75 by a solid rubber covered pressure roll 73 pressing against the fabric and web at 180 pli and thereby transferring the web to the dryer. A small amount of a solution consisting of polyvinyl alcohol, Crepetrol 190 and phosphate were sprayed on the dryer surface through spray head 76 to assist in the transfer and give enough web adhesion for good creping. The web was then dried to about 5% moisture, creped off of the dryer surface and wound into a roll. The dryer speed was 76 fpm and the angle of the creping pocket was about 90°. The through-dried base sheet 81 was then plied together with a similar web 82 with the dryer sides turned outward and calendered at 300 fpm at 75 pli in a rubber-steel nip and 100 pli in a steel to steel nip. The calendered two-ply product was then edge crimped, slit, interfolded, compressed and boxed into 200 sheet count white unlabelled facial tissue boxes. The physical properties of the facial tissue were tested with the results shown in Table III.

EXAMPLE 6

A paper web was formed using the same experimental equipment as that of Example 5 except that the web was formed from a single layer of virgin furnish chemical pulp and a relatively coarse through-drying and impression fabric of a mesh of 40×48 was used rather than the fabric. The furnish consisted of 75% northern softwood kraft and 25% northern hardwood kraft. The mixed furnish was lightly refined and had 0.3% wet strength resin added to it. The web was formed at a dryer basis weight of 7.0 lbs/2880 ft² and dewatered with vacuum boxes on the forming section to about 20% consistency. It was then transferred by means of vacuum to the 40×48 through-drying and impression fabric where it was further dried to 75% to 80% consistency by passing hot air at 160—170°F. through the web and fabric.

The moist web 86 was then pressed against a steam heated dryer by a solid rubber covered pressure roll pressing against the fabric and web at 180 pli and transferring the web to the dryer. A small amount of a solution consisting of 0.2% polyvinyl acetate, 0.5% Crepetrol 190 and 0.1% sodium phosphate was sprayed on the dryer surface to assist in the transfer and given enough sheet adhesion for good creping. The web 86 was then dried to about 5% moisture, creped off of the dryer surface and wound into a roll. The dryer speed was 70 fpm and the angle of the creping pocket was 80 to 90°.

The through-dried base sheet 85 was then plied together with the dryer sides turned outward and calendered at 300 fpm at 30 pli in a rubber-steel nip and 60 pli in a steel-to-steel nip. The calendered two-ply product was then edge crimped, slit, as C-folded. The physical properites of the facial tissue are listed in Table III

TABLE III

Physical Properties

	Ex. 5	Ex. 6	Commercial Code O	Tissues Code U
Basis Weight lbs/2880 ft²	16.5	16.4	18.4	19.9
Tensile Strength				
gms-machine direction	1165	1715	1455	1390
cross direction-Dry	555	600	370	595
cross direction-Wet	115	140	95	180
% stretch	9	6	14	20
Subjective Softness	6.0—6.5	5.5—6.0	5.0	5.0—6.0
Subjective Smoothness	5.0—6.0	5.0—6.0	4.5	6.5

EXAMPLE 7

Another comparison made is that of a through-dried two-ply bathroom tissue produced with webs of the fine mesh 78×72 fabric and virgin furnish and consumer use tested against a leading commercially produced two-ply bathroom tissue.

A continuous web of paper was manufactured at a speed of 2300 fpm from a furnish consisting of 50% northern softwood kraft, 33.3% northern hardwood kraft and 16.7% machine broke. 0.1% optical whitener and 0.1% sodium phosphate was added to the pulper and the furnish was lightly refined. A web was formed at a dryer basis weight of 7.3 lbs/2880 ft² on a tissue machine as in Figure 1. The outer forming fabric 1 and the inner or dewatering fabric 10 were conventional polyester forming fabrics. The formed web carried on the underside of the dewatering fabric 10 was then vacuum dewatered and transferred to a through-drying unit 24. The transfer was made with the aid of a pickup shoe 18 operating at about 3.8" Hg vacuum to a coarse commercially available through-drying fabric 19 of a mesh of 31×25 (775 openings per square inch). The fibre consistency after transfer was about 25%. The web on the through-drying fabric 19 was then further thermally dried by pulling hot air through the web and supporting fabric and transferred with the aid of a vacuum roll 29 to a lightly surfaced fine mesh transfer and impression fabric of a 78×72 mesh (5616 openings per square inch). The consistency immediately before the transfer was 85.2%. The moist web carried by the fine transfer fabric was then impressed on the surface by a Yankee dryer by a rubber covered 40 P&J hardness rubber covered roll at pressure of about 200 pli. A minor amount of creping adhesive consisting of Crepetrol 190, Cynol and tetrasodium pyrophosphate was sprayed onto the Yankee dryer surface immediately ahead of the pressure roll nip in order to control adhesion for creping. The web was then dried to 3.6% dryness, creped from the surface of the Yankee dryer and wound into rolls on the reel. The creping blade was ground with a 10° bevel and was held against the dryer so as to maintain a creping pocket of about 80°. The crepe ratio was 1.17, that is, about 17% stretch.

The through-dried bathroom tissue was then plied together with the dryer sides turned outward, calendered at 10 pli in a rubber-steel nip and 10 pli in a steel-to-steel nip, and wound into a roll. The

two-ply roll was then converted into 380 sheet count two-ply bathroom tissue and scented with a light fragrance.

Physical properties of the bathroom tissues as compared with a standard commercial produced product as shown in Table IV.

TABLE IV

Physical Properties

	Example 7	Commercially Produced Product
Roll Weight O.D. (gms)	137.2	140.9
Roll Diameter (inches)	4.84	4.64
Dry Tensile-MD	1115	1070
(gm/3 inch)-CD	620	646
% MD Stretch	14	17.5
Bulk (in/20 ply)	.086	.098
Absorbent Rate (sec.)	1	2.8
Finished Basis Weight (lb/2880 ft²)	17.3	17.5
Subjective Softness	6.5	6.8
Subjective Smoothness	4.5	3.8

EXAMPLE 8

A base web suitable for two-ply bathroom tissue was made by a process very similar to that of Example 7 except that a finer mesh transfer and impression fabric was used. A tissue machine as in Figure 1 was used to produce a continuous web of creped tissue at a Yankee dryer speed of 2300 fpm. A lightly refined furnish consisting of 62.5% northern softwood kraft, 20.8% southern hardwood kraft, and 16.7% machine broke was employed. The web was formed at a dryer basis weight of 7.1 lbs/2880 ft² on a tissue machine as shown in Figure 1. The outer forming fabric 1 and the inner or dewatering fabric 10 were conventional polyester forming fabrics. The formed web carried on the underside of the dewatering fabric 10 was then vacuum dewatered and transferred to through-drying unit 24 with the aid of a pickup shoe 18 operating at about 4.5" Hg. vacuum. The transfer was made to a coarse commercially available through-drying fabric 19 of a mesh of 31×25, that is, 775 openings per square inch. The fibre consistency after transfer was about 22.5% The web on the through-drying fabric 19 was then further thermally dried by pulling hot air through the web and supporting fabric. Then transfer was made with the aid of a vacuum roll 29 to a fine mesh transfer and impression fabric having 6340 openings per square inch, that is, of a 92×70 mesh and with filament diameters of about 0.006 inch. The consistency immediately after the transfer was about 89.0%. The moist web carried by the transfer fabric was then impressed on the surface of a Yankee dryer and dried and creped in the manner described in Example 7. The creping blade in this case was ground with a 5° bevel and was held against the dryer to maintain a creping pocket of about 85°. Despite the finer fabric mesh, the bulk at comparable strength and basis weight was about the same as a similar product made with a fabric having 5616 openings per square inch as shown below.

Openings per Square Inch Impression Fabric	MD Tensile 2 Ply	% Stretch	CD Tensile 2 Ply	Finished Basis Weight	Dryer Basis Weight	20 Ply Bulk
5340	1162	21.6	428	8.2	7.1	.138
5616	1244	28.9	532	9.1	7.1	.142

The following tests were employed in securing the data set out hereinbefore.

The tissue softness determination is a subjective procedure in which experienced operators grade samples against a standard and involves the effect of limpness and surface texture. Grading is on the basis of a scale of 1 to 7 with the number 7 representing the softest.

The tissue smoothness is also determined on a subjective basis by experienced operators against a standard and involves moving the hand over the sheet both with and against the crepe and further includes finger tip evaluation under very light pressure of the surface. Grading los on a number scale in which the higher numbers indicated the smoother sheet, the number 8 being assigned to the most smooth condition.

The absorbent rate is determined by stapling 40 plies of the sample web or sheet together at each corner and dropping the composite flat on the water with points of the staples in the down position and timed from the time of contact with the water until it is completely wetted out. Absorbent rate is reported as the sink time or time to completely wet out measured in seconds to the nearest tenth second.

The absorbent capacity is measured essentially by immersing a weighed 4"×4" sample in water for three minutes, removing the sample and allowing free water to drip off for one minute and then weighing the wetted sample. The capacity is the difference in weight between the wetted and dry sample divided by the dry weight and expressed in grams of water per gram of fibre.

The 20 ply bulk factor is obtained by placing 20 plies of the tissue, either as 20 individual plies or as ten two ply sheets on a platform. A three inch diameter cylinder loaded at 220 gms/sq. inch is lowered onto the 20 plies and their thickness in thousandths of an inch is recorded.

In the practice of the invention, square weave or diagonal weave fabrics may be employed and the fabric may be of mono or multifilament structure and twilled or semi-twilled, for example.

The product employing a printing and impression fabric of at least 4900 opoenings per square inch has approximately 70 crepes per inch and a pressed knuckled area of about 20—25% of the tissue surface. The absorbency of such sheets is greater than that of conventionally pressed tissues and approximates that of through-dried tissues of the art while yet having a greater crepes per inch which contributes to smoothness and softness, and also having a bulk density comparable to that of through-dried tissue. For example, at about 90 crepes per inch the web absorbency has a rating of about 6 to 8 in contrast to a rating of about 8 for a much more coarsely creped web having approximately 60 crepes per inch and the bulk densities of the two webs are very nearly the same. Apparently such characteristics present a tactile response which favours the finer crepe product.

CLAIMS

1. A process for the production of a smooth tissue having a basis weight, uncreped, of between about 5 and 25 pounds per 2880 sq. ft. comprising the steps of wet forming a paper web of wood pulp fibres in the substantial absence of pressure to minimize interfibre bonding, through-drying the formed unpressed web to a fibre consistency in the range of about 40% to about 90%, carrying the so through-dried web on an imprinting and transfer fabric having between about 4900 and 8100 openings per square inch and imprinting the knuckle pattern of the fabric into the web to provide bonded zones and bulked unbonded zones between the bonded zones while continuing drying of the web, and creping the bonded web to provide a web of at least about 70 crepes per inch and having a high degree of smoothness.

2. A process as claimed in Claim 1 in which the wet web is through-dried on one fabric and then transferred to the imprinting and transfer fabric at a fibre consistency in the range of about 40—90% for imprinting of the knuckle pattern of the fabric and creping.

3. A creped tissue paper web having a basis weight in the range of between about 5 and 25 pounds per 2800 sq. ft. and a knuckle pattern occupying between about 20 and 25% of the web surface area, said knuckle pattern being that of an imprinting fabric having greater than 4900 openings per square inch and less than about 8100 openings per square inch.

4. A tissue paper web as claimed in Claim 3 in which the knuckle pattern is that of an imprinting fabric having a mesh of 78×72.

5. A tissue paper web as claimed in Claim 3 in which the knuckle pattern is that of an imprinting fabric having a mesh of 92×70.

6. A tissue paper web substantially as hereinbefore described with reference to any of Figures 2 to 4, 6 and 7 of the accompanying drawings or with reference to any of the Examples.

7. A process for the production of a tissue paper web substantially as hereinbefore described.

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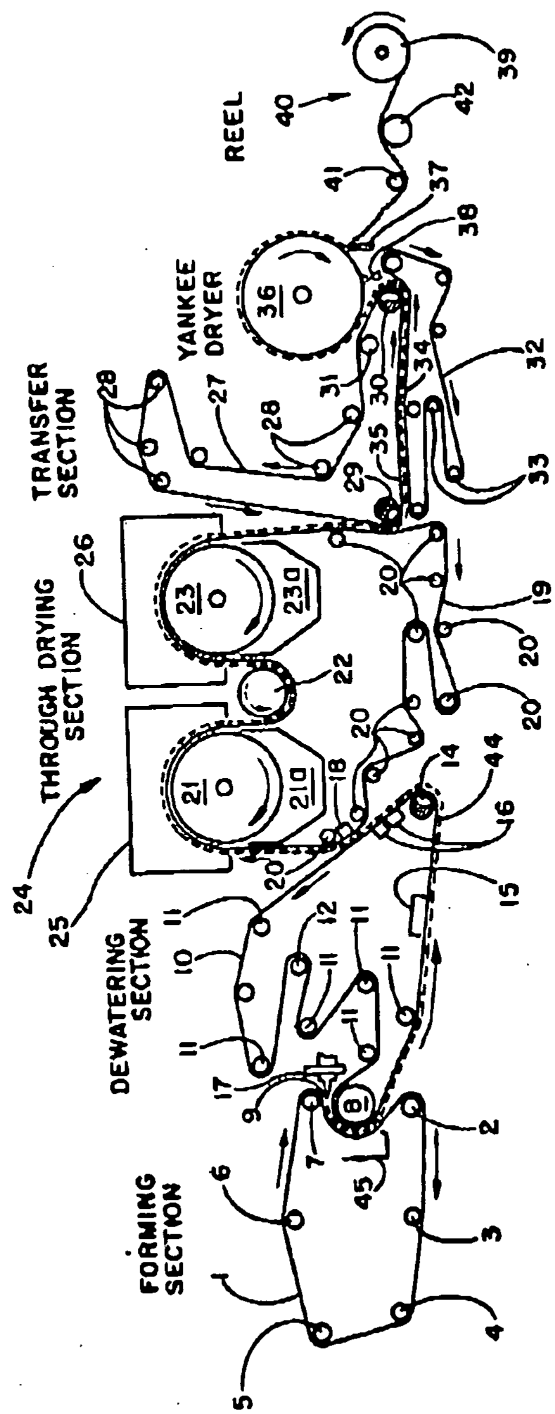

FIG. 1

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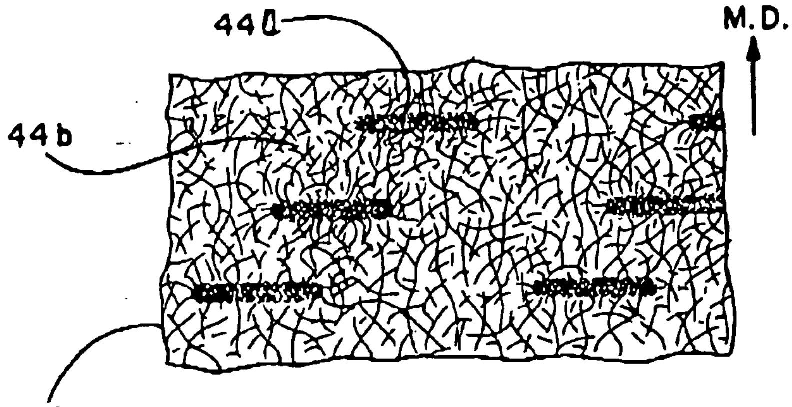


FIG. 2A

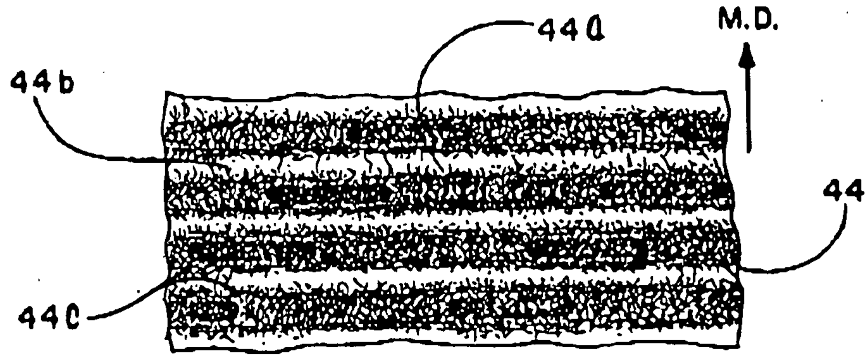
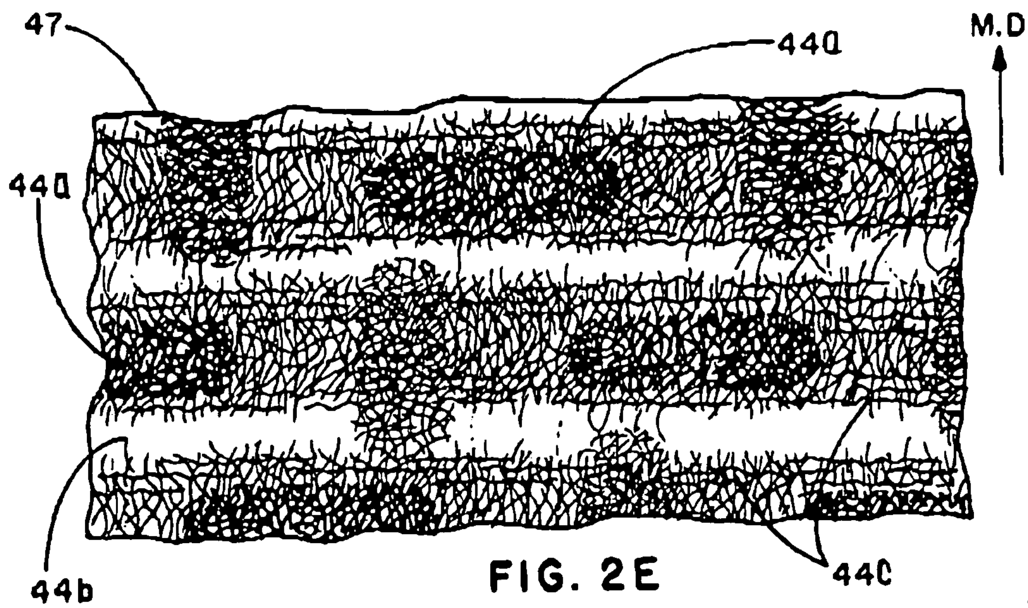


FIG. 2B



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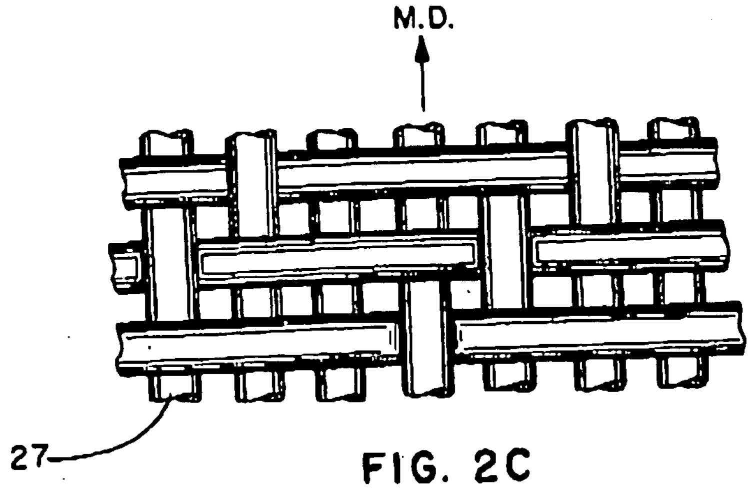

FIG. 2C

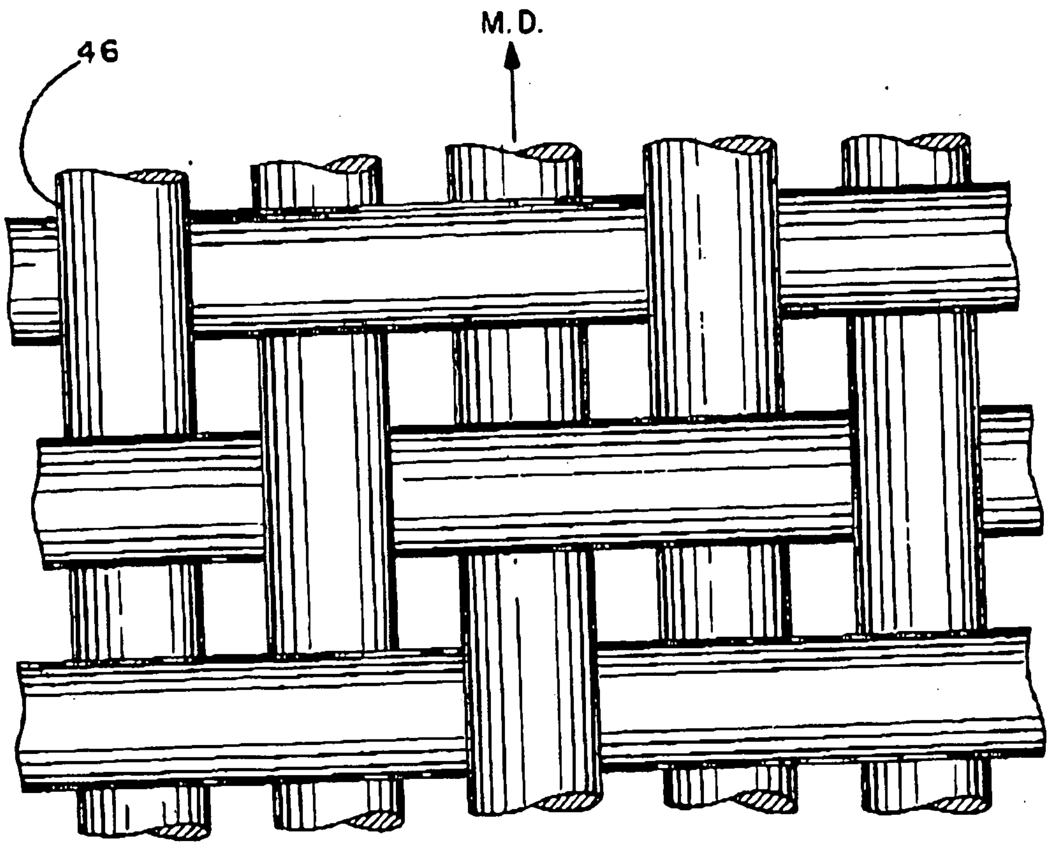

FIG. 2D

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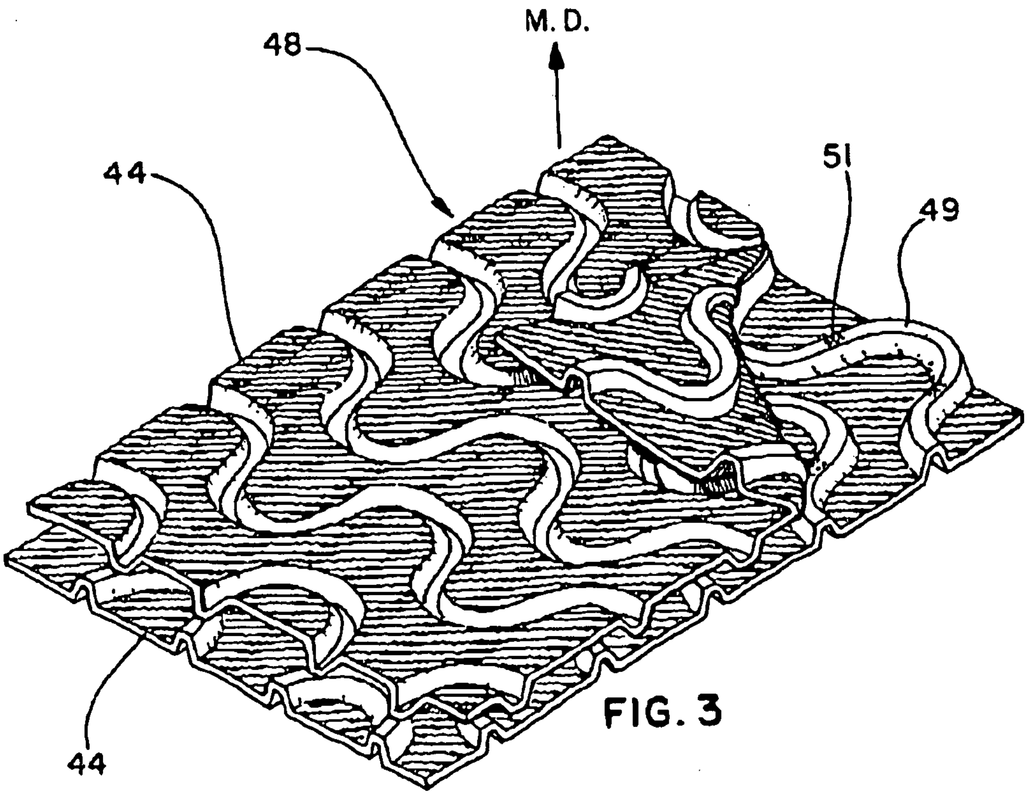

FIG. 3

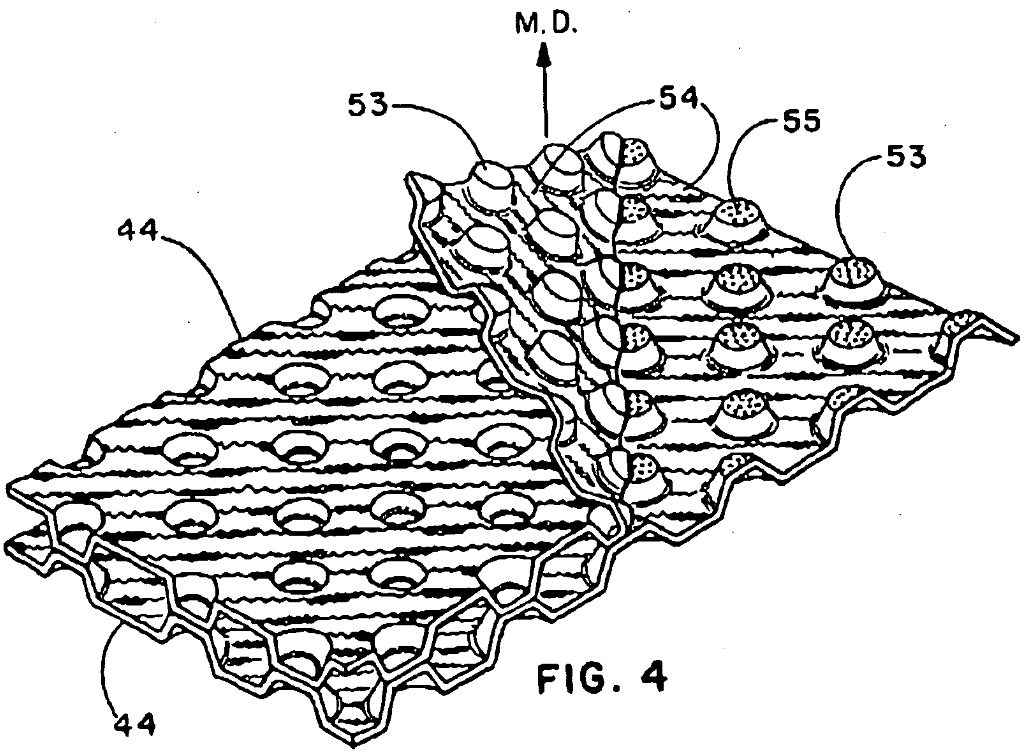

FIG. 4

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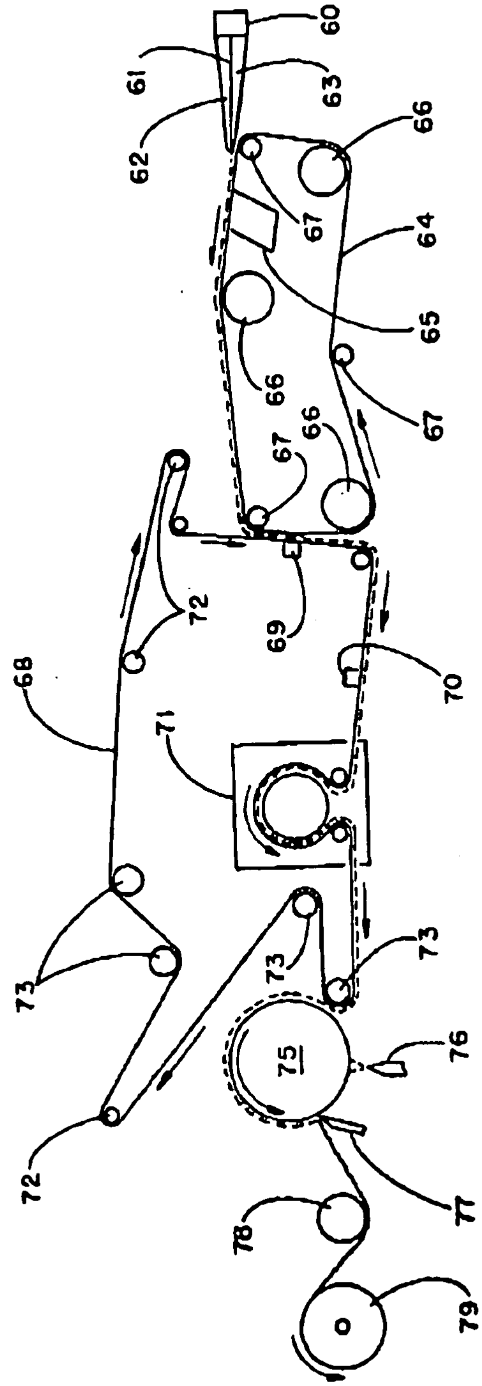

FIG. 5

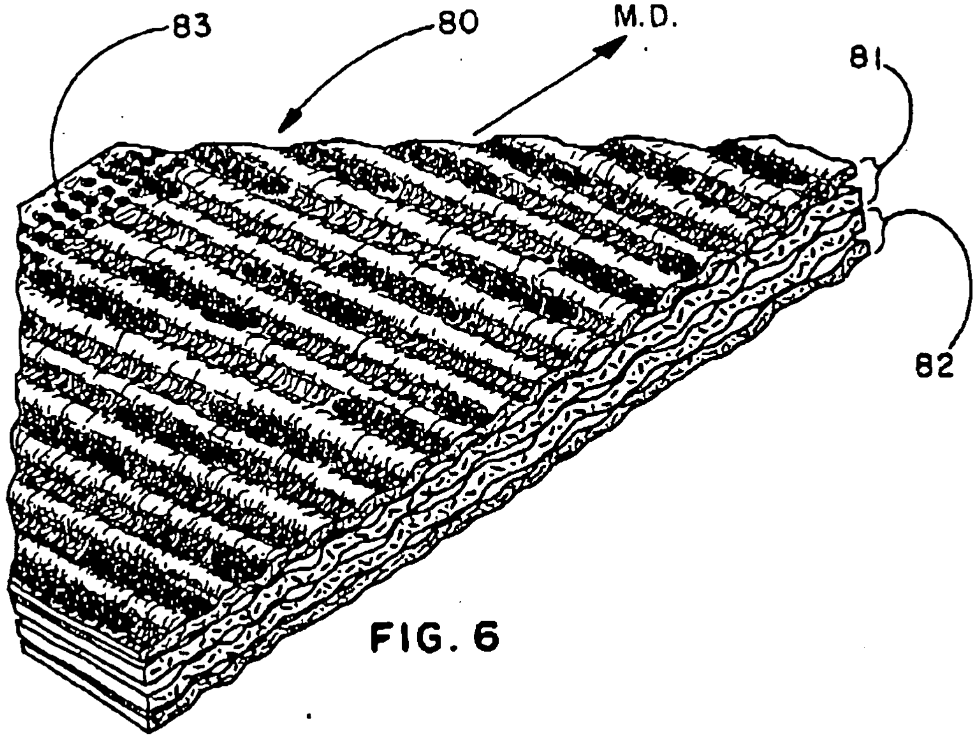

FIG. 6

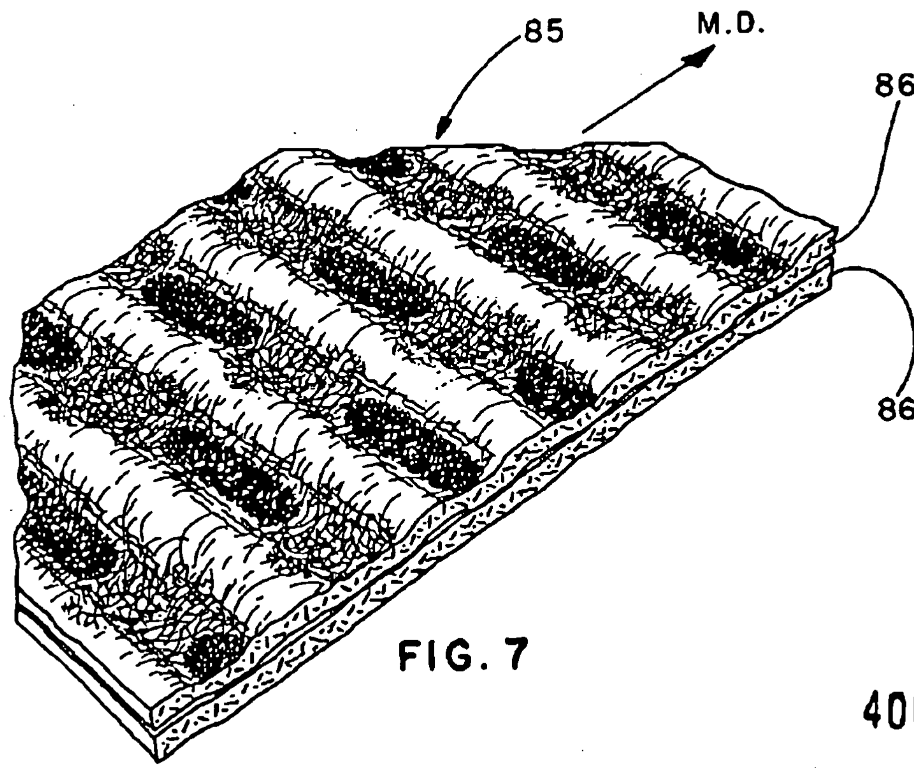

FIG. 7

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